CLAIMS

What is claimed is:

1. A method for removing phosphorus from a wastewater effluent stream comprising the steps of:

(a) introducing wastewater effluent to the bottom of a continuous crystallizer comprising a fluidized bed of struvite therein and a struvite crystal collection chamber therebeneath, said crystallizer being formed such that the cross sectional area thereof generally increases from a relatively smaller cross sectional area at the bottom thereof to a relatively larger cross sectional area at the top thereof;

(b) introducing an effective amount of ammonia to the wastewater effluent at the bottom of the crystallizer to elevate the wastewater stream effluent pH range a predetermined amount;

(c) introducing an effective amount of magnesium to the wastewater effluent at the bottom of the crystallizer;

(d) continuously passing the composition-adjusted wastewater effluent upwardly through the fluidized bed of struvite to reduce the total phosphorus content of the wastewater effluent a predetermined amount;

(e) removing the treated wastewater effluent from the top of the crystallizer; and

(f) periodically removing struvite crystals that grow large enough to sink from the bottom of the crystallizer into the collection chamber.

2. The method according to claim 1 including providing an inverted cone-shaped continuous crystallizer about 60 inches high and about 1.5 inches in diameter at the bottom and about 10.0 inches in diameter at the top.

3. The method according to claim 1 including providing an inverted cone-shaped continuous crystallizer including a cone-shaped plug valve at the bottom thereof for selectively operating and purging the continuous crystallizer.

4. The method according to claim 1 including providing an ammonia addition to the wastewater effluent stream that results in an ammonia addition of up to about 200 ppm or more and a pH addition of up to about 1.0 pH or more.

5. The method according to claim 1 including providing a magnesium addition to the wastewater effluent stream that results in a magnesium addition of up to about 60 ppm or more.

6. The method according to claim 1 including producing the magnesium added to the wastewater effluent by a combination of adding gaseous CO_2 to the wastewater effluent and then passing the effluent through a magnesite bed to produce the magnesium added to the wastewater effluent at the bottom of the crystallizer.

7. The method according to claim 1 including providing livestock waste lagoon effluent as the wastewater effluent.

8. The method according to claim 1 including reducing the total phosphorus content of the wastewater effluent is a predetermined amount of up to about 80% or more.

9. An apparatus for removing phosphorus from a wastewater effluent stream comprising:

(a) a continuous crystallizer tower comprising a fluidized bed of struvite therein and a struvite crystal product collection chamber therebeneath, said crystallizer being formed such that the cross sectional area thereof generally increases from a relatively smaller cross sectional area at the bottom thereof to a relatively larger cross sectional area at the top thereof;

(b) a dissolver tower comprising a bed of magnesite therein;

(c) a first pump for pumping a first portion of the wastewater effluent to the bottom of the continuous crystallizer and a second portion of the wastewater effluent to the bottom of the dissolver tower;

(d) a second pump for pumping magnesium overflow solution from the top of the dissolver tower to the bottom of the continuous crystallizer tower;

(e) an ammonia source for injecting ammonia into the first portion of the wastewater effluent at the bottom of the continuous crystallizer;

(f) a carbon dioxide (CO_2) source for injecting carbon dioxide into the second portion of the wastewater effluent at the bottom of the dissolver tower; and

(g) a drain for capturing the treated wastewater effluent from the top of the continuous crystallizer tower.

10. The apparatus according to claim 9 wherein the crystallizer tower comprises an inverted cone-shaped tower about 60 inches high and about 1.5 inches in diameter at the bottom and 10.0 inches in diameter at the top.

11. The apparatus according to claim 9 wherein the apparatus operates at up to about 600 L/h of total liquid flow therethrough.

12. The apparatus according to claim 9 wherein the crystallizer includes a plug valve at the bottom thereof for selectively operating and purging the continuous crystallizer.

13. The apparatus according to claim 9 wherein the dissolver tower comprises an inverted cone-shaped tower with a cone-shaped plug valve at the bottom thereof.

14. The apparatus according to claim 9 wherein the first pump comprises a centrifugal pump.

15. The apparatus according to claim 9 wherein the second pump comprises a variable speed gear pump.

16. The apparatus according to claim 9 wherein the ammonia source comprises a pressurized ammonia cylinder.

17. The apparatus according to claim 9 wherein the CO_2 source comprises a pressurized CO_2 cylinder.

18. The apparatus according to claim 9 wherein the drain conducts treated wastewater effluent to a storage reservoir.

19. The apparatus according to claim 9 including a tank for receiving magnesium overflow solution directly from the dissolver tower and from which the second pump then pumps the solution to the bottom of the equalizer tower.

20. The apparatus according to claim 19 including a float valve on the tank for maintaining a proper level of magnesium in the tank.